

APPENDIX XVII TO PART 86—PROCEDURE FOR DETERMINING VEHICLE EMISSION CONTROL TECHNOLOGY CATEGORY/FUEL REACTIVITY ADJUSTMENT FACTORS FOR LIGHT-DUTY VEHICLES AND LIGHT LIGHT-DUTY TRUCKS CERTIFYING TO THE PROVISIONS OF PART 86, SUBPART R

The following procedure shall be used by the Administrator to establish the reactivity adjustment factor for exhaust emissions of non-methane organic gases (NMOG) and establish the "methane reactivity adjustment factor" for exhaust methane emissions from natural gas vehicles, for the purpose of certifying a vehicle of specific emission control technology category and fuel for the National LEV program provisions of subpart R of this part.

(a) The Administrator shall determine representative speciated NMOG exhaust emission profiles for light-duty conventional gasoline-fueled TLEVs, LEVs, and ULEVs according to the following conditions:

(1) All testing will be conducted using a specified gasoline blend representative of commercial gasoline and having the specifications listed in § 86.1771.

(2) Speciated NMOG profiles shall be obtained from a statistically valid number of TLEVs, LEVs, and ULEVs.

(3) The speciated NMOG profiles shall identify and quantify, in units of g/mile or mg/mile, as many constituents as possible in accordance with the procedures specified in Chapter 5 of the California Regulatory Requirements Applicable to the National Low Emission Vehicle Program (October, 1996). These procedures are incorporated by reference (see § 86.1).

(b) The "g ozone potential per mile" of each NMOG identified in the speciated profile shall be determined by multiplying the "g/mile NMOG" emission value of the constituent NMOG by its maximum incremental reactivity in paragraph (j) of this appendix.

(c) The "total g ozone potential per mile" of NMOG exhaust emissions from the vehicle/fuel system shall be the sum of all the constituent NMOG "g ozone potential per mile" values calculated in paragraph (b) of this appendix.

(d) The "g ozone potential per g NMOG" for the vehicle/fuel system shall be determined by dividing the "total g ozone potential per mile" value calculated in paragraph (c) of this appendix by the "total g/mile of NMOG emissions".

(e) For light-duty candidate vehicle/fuel systems not powered by conventional gasoline, the Administrator shall establish "reactivity adjustment factors" calculated from exhaust emission profiles derived according to the same conditions specified in paragraphs (a)(1) and (a)(2) of this appendix.

(f) The "g ozone potential per g NMOG" for candidate vehicle/fuel systems not powered by conventional gasoline shall be determined according to paragraphs (b), (c), and (d) of this appendix.

(g)(1) The candidate vehicle/fuel "reactivity adjustment factor" shall be determined by dividing the "g ozone potential per g NMOG" calculated in paragraph (f) of this appendix by the "g ozone potential per g NMOG" value for the vehicle in the same emission control technology category operated on conventional gasoline. The "g ozone potential per g NMOG" values for conventional gasoline vehicles are listed in § 86.1777(b)(5) or shall be established by the Administrator pursuant to this appendix.

dix. For candidate vehicle/fuel systems powered by methanol or liquefied petroleum gas, the quotient calculated above shall be multiplied by 1.1. The resulting value shall constitute the "reactivity adjustment factor" for the methanol or liquefied petroleum gas-powered vehicle/fuel system.

(2) For candidate vehicle/fuel systems operating on natural gas, a "methane reactivity adjustment factor" shall be calculated by dividing the maximum incremental reactivity value for methane given in paragraph (j) of this appendix by the "g ozone potential per g NMOG" value for the vehicle in the same emission control technology category operated on conventional gasoline as listed in § 86.1777(b)(5) or established by the Administrator pursuant to this appendix.

(h) The Administrator shall assign a reactivity adjustment factor unique to a specific engine family at the request of a vehicle manufacturer provided that each of the following occurs:

(1)(i) The manufacturer submits speciated NMOG exhaust emission profiles to the Administrator obtained from emission testing a minimum of four different vehicles representative of vehicles that will be certified in the engine family. The test vehicles shall include the official emission-data vehicle(s) for the engine family, and the mileage accumulation of each vehicle shall be at or greater than 4000 miles. One speciated profile shall be submitted for each test vehicle. Emission levels of each constituent NMOG shall be measured according to Chapter 5 of the California Regulatory Requirements Applicable to the National Low Emission Vehicle Program (October, 1996). These procedures are incorporated by reference (see § 86.1). For the emission-data vehicle(s), the speciated profile(s) shall be obtained from the same test used to obtain the official exhaust emission test results for the emission-data vehicle at the 4,000 mile test point. The manufacturer shall calculate "g ozone potential per g NMOG" values for each speciated NMOG exhaust emission profile in accordance with the procedures specified in paragraphs (b), (c), and (d) of this appendix. By using these "g ozone potential per g NMOG" values, the manufacturer shall calculate a "reactivity adjustment factor" for each test vehicle in accordance with the procedure specified in paragraph (g) of this appendix. A "reactivity adjustment factor" for the engine family shall be calculated by taking the arithmetic mean of the "reactivity adjustment factor" obtained for each test vehicle. The 95 percent upper confidence bound (95% UCB) shall be calculated according to the equation:

$$ER06JN97.003$$

Where:

$RAF_m$  = mean "reactivity adjustment factor" calculated for the engine family.

$RAF_i$  = "reactivity adjustment factor" calculated for the i'th test vehicle.

n = number of test vehicles.

(ii) The 95 percent upper confidence bound of the "reactivity adjustment factor" for the engine family shall be less than or equal to 115 percent of the engine family "reactivity adjustment factor."

(2) The manufacturer submits an "ozone deterioration factor" for the engine family. To determine the "ozone deterioration factor," the manufacturer shall perform two tests at each mileage interval for one or more durability vehicle(s) tested in accordance with the procedures and

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conditions specified in subpart R of this part for calculating mass deterioration factors. The Administrator shall approve the use of other mileage intervals and procedures if the manufacturer can demonstrate that equivalently representative "ozone deterioration factors" are obtained. One speciated profile shall be submitted for each test. Emission levels of each constituent NMOG shall be measured according to Chapter 5 of the California Regulatory Requirements Applicable to the National Low Emission Vehicle Program (October, 1996). These procedures are incorporated by reference (see § 86.1). A mean g/mi NMOG mass value and a mean "g ozone per g NMOG" value shall be calculated by taking the arithmetic mean of each measurement from the speciated profiles. These results shall be multiplied together to obtain a mean "total g ozone potential per mile" value at each mileage interval. A mean "ozone deterioration factor" shall be calculated in accordance with the procedures in § 86.1777 and this appendix except that the mean total "g ozone potential per mile" value determined at each mileage interval shall be used in place of measured mass emissions. If the "ozone deterioration factor" is determined to be less than 1.00, the "ozone deterioration factor" shall be assigned a value of 1.00. The "ozone deterioration factor" shall be multiplied by the product of the official exhaust NMOG mass emission results at the 4000 mile test point and the mean "reactivity adjustment factor" for the engine family to obtain the NMOG certification levels used to determine compliance with the NMOG emission standards.

(3) The speciated profiles, mean "reactivity adjustment factor" for the engine family, and "ozone deterioration factor" are provided to the Administrator with the certification application for the engine family.

(i) Gasoline meeting the specifications listed in the following tables shall be used to determine the "g ozone potential per g NMOG" of conventional gasoline (the test methods used for each fuel property shall be the same as the test method for the identical fuel property listed in § 86.1771):

Fuel property	Limit
Sulfur, ppm by weight .....	300 ± 50
Benzene, volume percent .....	1.6 ± 0.3
Reid vapor pressure, psi .....	8.7 ± 0.3
Distillation, D-86 degrees F	
10% .....	115-135
50%, maximum .....	240
90% .....	323-333
EP, maximum .....	420
Hydrocarbon Type, volume percent	
Total Aromatics .....	32 ± 3.0
Multi-substituted alkyl aromatics .....	21 ± 3.0
Olefins .....	12 ± 3.0
Saturates .....	remainder

(j) The maximum incremental reactivities to be used in paragraph (b) of this appendix are provided in the table in this paragraph (j). Any manufacturer which intends to use the table shall submit to the Administrator a list which provides the specific organic gases measured by the manufacturer and the maximum incremental reactivity value assigned to each organic gas prior to or with the submittal of a request for the use of a reactivity adjustment factor unique to a specific engine family. The Ad-

ministrator may deny such requests if he or she determines that the maximum incremental reactivity value assignments are made incorrectly. The table follows:

MAXIMUM INCREMENTAL REACTIVITY (MIR) VALUES  
[Units: grams ozone/gram organic gas]

CAS#	Compound	MIR
Alcohols		
00067-56-1 .....	methanol .....	0.56
00064-17-5 .....	ethanol .....	1.34
Light End and Mid-Range Hydrocarbons (Listed in approximate elution order)		
00074-85-1 .....	methane .....	0.0148
00074-86-2 .....	ethene .....	7.29
00074-84-0 .....	ethyne .....	0.50
00115-07-1 .....	ethane .....	0.25
00074-98-6 .....	propene .....	9.40
00463-49-0 .....	propane .....	0.48
00074-99-7 .....	1,2-propadiene .....	10.89
00075-28-5 .....	1-propyne .....	4.10
00115-11-7 .....	methylpropane .....	1.21
00106-98-9 .....	2-methylpropene .....	5.31
00106-99-0 .....	1-butene .....	8.91
00106-97-8 .....	1,3-butadiene .....	10.89
00624-64-6 .....	n-butane .....	1.02
00463-82-1 .....	trans-2-butene .....	9.94
00107-00-6 .....	2,2-dimethylpropane .....	0.37
00590-18-1 .....	1-butyne .....	9.24
00563-45-1 .....	cis-2-butene .....	9.94
00078-78-4 .....	3-methyl-1-butene .....	6.22
00503-17-3 .....	2-methylbutane .....	1.38
00109-67-1 .....	2-butyne .....	9.24
00563-46-2 .....	1-pentene .....	6.22
00109-66-0 .....	2-methyl-1-butene .....	4.90
00078-79-5 .....	n-pentane .....	1.
00646-04-8 .....	2-methyl-1,3-butadiene .....	9.08
00558-37-2 .....	trans-2-pentene .....	8.80
00627-20-3 .....	3,3-dimethyl-1-butene .....	4.42
00689-97-4 .....	cis-2-pentene .....	8.80
00513-35-9 .....	1-buten-3-yne .....	9.24
00542-92-7 .....	2-methyl-2-butene .....	6.41
00075-83-2 .....	1,3-cyclopentadiene .....	7.66
00142-29-0 .....	2,2-dimethylbutane .....	0.82
00691-37-2 .....	cyclopentene .....	7.66
00760-20-3 .....	4-methyl-1-pentene .....	4.42
00287-92-3 .....	3-methyl-1-pentene .....	4.42
00079-29-8 .....	cyclopentane .....	2.38
01634-04-4 .....	2,3-dimethylbutane .....	1.07
00691-38-3 .....	1-methyl-tert-butyl-ether .....	0.62
00107-83-5 .....	4-methyl-cis-2-pentene .....	6.69
00674-76-0 .....	2-methylpentane .....	1.53
00096-14-0 .....	4-methyl-trans-2-pentene .....	6.69
00763-29-1 .....	3-methylpentane .....	1.52
00592-41-6 .....	2-methyl-1-pentene .....	4.42
00110-54-3 .....	1-hexene .....	4.42
13269-52-8 .....	n-hexane .....	0.98
07642-09-3 .....	trans-3-hexene .....	6.69
04050-45-7 .....	cis-3-hexene .....	6.69
00616-12-6 .....	trans-2-hexene .....	6.69
00625-27-4 .....	3-methyl-trans-2-pentene .....	6.69
01120-62-3 .....	2-methyl-2-pentene .....	6.69
07688-21-3 .....	3-methylcyclopentene .....	5.65
00637-92-3 .....	cis-2-hexene .....	6.69
00922-62-3 .....	1-ethyl-tert-butyl-ether .....	1.98
00590-35-2 .....	3-methyl-cis-2-pentene .....	6.69
00096-37-7 .....	2,2-dimethylpentane .....	1.40
00108-08-7 .....	methylcyclopentane .....	2.82
00464-06-2 .....	2,4-dimethylpentane .....	1.78
07385-78-6 .....	2,2,3-trimethylbutane .....	1.32
00693-89-0 .....	3,4-dimethyl-1-pentene .....	3.48
00071-43-2 .....	1-methylcyclopentene .....	7.66
03404-61-3 .....	benzene .....	0.42
00562-49-2 .....	3-methyl-1-hexene .....	3.48
00110-82-7 .....	3,3-dimethylpentane .....	0.71
00591-76-4 .....	cyclohexane .....	1.28
00565-59-3 .....	2-methylhexane .....	1.08
00110-83-8 .....	2,3-dimethylpentane .....	1.51
00589-34-4 .....	cyclohexene .....	5.67
02532-58-3 .....	3-methylhexane .....	1.40
00617-78-7 .....	cis-1,3-dimethylcyclopentane .....	2.55
00822-50-4 .....	3-ethylpentane .....	1.40
00592-76-7 .....	trans-1,2-dimethylcyclopentane .....	1.85
00540-84-1 .....	1-heptene .....	3.48
	2,2,4-trimethylpentane .....	0.93

MAXIMUM INCREMENTAL REACTIVITY (MIR) VALUES—  
Continued  
[Units: grams ozone/gram organic gas]

CAS#	Compound	MIR
14686-14-7	trans-3-heptene	5.53
00142-82-5	n-heptane	0.81
02738-19-4	2-methyl-2-hexene	5.53
03899-36-3	3-methyl-trans-3-hexene	5.53
14686-13-6	trans-2-heptene	5.53
00816-79-5	3-ethyl-2-pentene	5.53
00107-39-1	2,4,4-trimethyl-1-pentene	2.69
10574-37-5	2,3-dimethyl-2-pentene	5.53
06443-92-1	cis-2-heptene	5.53
00108-87-2	methylcyclohexane	1.85
00590-73-8	2,2-dimethylhexane	1.20
00107-40-4	2,4,4-trimethyl-2-pentene	5.29
01640-89-7	ethylcyclopentane	2.31
00592-13-2	2,5-dimethylhexane	1.63
00589-43-5	2,4-dimethylhexane	1.50
00563-16-6	3,3-dimethylhexane	1.20
00565-75-3	2,3,4-trimethylpentane	1.60
00560-21-4	2,3,3-trimethylpentane	1.20
00108-88-3	toluene	2.73
00584-94-1	2,3-dimethylhexane	1.32
00592-27-8	2-methylheptane	0.96
00589-53-7	4-methylheptane	1.20
00589-81-1	3-methylheptane	0.99
15890-40-1	(1a,2a,3b)-1,2,3-trimethylcyclopentane	1.94
00638--0	cis-1,3-dimethylcyclohexane	1.94
02207--7	trans-1,4-dimethylcyclohexane	1.94
03522-94-9	2,2,5-trimethylhexane	0.97
00111-66-0	1-octene	2.69
14850-23-8	trans-4-octene	5.29
00111-65-9	n-octane	0.61
13389-42-9	trans-2-octene	5.29
02207-03-6	trans-1,3-dimethylcyclohexane	1.94
07642--8	cis-2-octene	5.29
01069-53-0	2,3,5-trimethylhexane	1.14
02213-23-2	2,4-dimethylheptane	1.34
02207-01-4	cis-1,2-dimethylcyclohexane	1.94
01678-91-7	ethylcyclohexane	1.94
00926-82-9	3,5-dimethylheptane	1.14
00100-41-4	ethylbenzene	2.70
03074-71-3	2,3-dimethylheptane	1.14
00108-38-3	m-&p-xylene	7.64
02216-34-4	4-methyloctane	1.14
03221-61-2	2-methyloctane	1.14
02216-33-3	3-methyloctane	1.14
00100-42-5	styrene(ethenylbenzene)	2.22
00095-47-6	o-xylene	6.46
00124-11-8	1-nonene	2.23
00111-84-2	n-nonane	0.54
00098-82-8	(1-methylethyl)benzene	2.24
15869-87-1	2,2-dimethyloctane	1.01
04032-94-4	2,4-dimethyloctane	1.01
00103-65-1	n-propylbenzene	2.12
00620-14-4	1-methyl-3-ethylbenzene	7.20
00622-96-8	1-methyl-4-ethylbenzene	7.20

MAXIMUM INCREMENTAL REACTIVITY (MIR) VALUES—  
Continued  
[Units: grams ozone/gram organic gas]

CAS#	Compound	MIR
00108-67-8	1,3,5-trimethylbenzene	10.12
00611-14-3	1-methyl-2-ethylbenzene	7.20
00095-63-6	1,2,4-trimethylbenzene	8.83
00124-18-5	n-decane	0.47
00538-93-2	(2-methylpropyl)benzene	1.87
00135-98-8	(1-methylpropyl)benzene	1.89
00535-77-3	1-methyl-3-(1-methylethyl)benzene	6.45
00526-73-8	1,2,3-trimethylbenzene	8.85
00099-87-6	1-methyl-4-(1-methylethyl)benzene	6.45
00496-11-7	2,3-dihydroindene(indan)	1.06
00527-84-4	1-methyl-2-(1-methylethyl)benzene	6.45
00141-93-5	1,3-diethylbenzene	6.45
00105-05-5	1,4-diethylbenzene	6.45
01074-43-7	1-methyl-3-n-propylbenzene	6.45
01074-55-1	1-methyl-4-n-propylbenzene	6.45
00135-01-3	1,2-diethylbenzene	6.45
01074-17-5	1-methyl-2-n-propylbenzene	6.45
01758-88-9	1,4-dimethyl-2-ethylbenzene	9.07
00874-41-9	1,3-dimethyl-4-ethylbenzene	9.07
00934-80-5	1,2-dimethyl-4-ethylbenzene	9.07
02870-04-4	1,3-dimethyl-2-ethylbenzene	9.07
01120-21-4	n-undecane(hendecane)	0.42
00933-98-2	1,2-dimethyl-3-ethylbenzene	9.07
00095-93-2	1,2,4,5-tetramethylbenzene	9.07
03968-85-2	(2-methylbutyl)benzene	1.07
00527-53-7	1,2,3,5-tetramethylbenzene	9.07
01074-92-6	1-(1,1-dimethylethyl)-2-methylbenzene	5.84
00488-23-3	1,2,3,4-tetramethylbenzene	9.07
00538-68-1	n-pentylbenzene	1.70
00098-19-1	1-(1,1-dimethylethyl)-3,5-DMbenzene	7.50
00091-20-3	naphthalene	1.18
00112-40-3	n-dodecane	0.38

Carbonyl Compounds

CAS#	Compound	MIR
00050-00-0	formaldehyde	7.15
00075-07-0	acetaldehyde	5.52
00107-02-8	acrolein	6.77
00067-64-1	acetone	0.56
00123-33-6	propionaldehyde	6.53
00123-72-8	butyraldehyde	5.26
00066-25-1	hexanaldehyde	3.79
00100-52-7	benzaldehyde	-0.55
00078-93-3	methyl ethyl ketone (2-butanone)	1.18
00078-85-3	methacrolein	6.77
04170-30-3	crotonaldehyde	5.42
00110-62-3	valeraldehyde	4.41
00620-23-5	m-tolualdehyde	-0.55

[62 FR 31266, June 6, 1997]

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